***Equation 3-5***

$$= \left(\frac{\qquad}{\qquad}\right) \times \left(\frac{[\quad / \ ]}{[\mu \quad / \epsilon]}\right)$$

Where:

$MDCR_{surveyor}$ = minimum detectable count rate surveyor
$\varepsilon_{imst}$ = instrument efficiency (cpm/µR/hr)
*Radionuclide Concentration* = modeled source term concentration (pCi/g)
*Exposure Rate* = result of model (microroentgen(s) per hour [µR/hr])

### 3.1.6.4 Example Gamma Scan Minimum Detectable Concentrations

An example a priori scan MDC calculation is provided herein for $^{226}$Ra using a Ludlum 2221 with a Model 44-20 (3-inch by 3-inch NaI) detector. This example assumes a background level of 18,000 cpm, and 95 percent correct detections and 95 percent false positive rates resulting in a *d'* of 3.28. A scan rate of 0.5 meter per second (m/s) (19.7 inches per second) provides an observation interval of 2 seconds (based on a diameter of approximately 1 meter for the modeled area of elevated activity). The $MDCR_{surveyor}$ was then calculated assuming a surveyor efficiency ($\rho$) of 1 (assumes automated data logging). The scan MDC is calculated as follows:

$$= 3.28\ g\sqrt{\frac{18{,}000\ g\,2}{60}} = 80$$

$$= 80\ g\left(\frac{60}{2}\right) = 2{,}410$$

$$= \frac{2{,}410}{\sqrt{1}} = 2{,}410$$

The relationship between the detector's net count rate and net exposure rate has been obtained from the detector manufacturer and is 2,300 cpm/µR/hr. The relationship between the radionuclide contamination and exposure rate has been determined by modeling (using Microshield) the source area to determine the net exposure rate produced by a given concentration of a radionuclide at a specific distance above the source. The Microshield Version 11.20 model has a source activity of 1 pCi/g of $^{226}$Ra, a circular area of elevated activity of 1 square meter, a contaminated zone depth of 15 centimeters (6 inches), and a soil density of 1.6 grams per cubic centimeter. The modeling code determined an exposure rate at the detector height (dose point) of 10 centimeters (4 inches) above the source to be 1.130 µR/hr. The scan MDC for this source geometry is calculated as follows:

$$= \left(\frac{2{,}410}{2{,}300 \quad /\mu \quad /\epsilon}\right) \times \left(\frac{1.0[\quad / \ ]}{1.130[\mu \quad /\epsilon]}\right) = 0.93 \quad /$$

Additional a priori determinations are provided in **Table 3-3**. The Microshield model parameters are identical to those described in the previous example, using either $^{226}$Ra with a concentration of 1 pCi/g, or $^{137}$Cs with a concentration of 0.113 pCi/g.

Table 3-3. A Priori Scan MDCs

| NaI Detector | Remediation Goal | Scan MDC |
|---|---|---|
| Ludlum 44-20, 3x3 | $^{226}$Ra, 1.0 pCi/g | 0.93 pCi/g |
| | $^{137}$Cs, 0.113 pCi/g | 2.30 pCi/g |
| Bicron 3SSL-X, 3x5x16 | $^{226}$Ra, 1.0 pCi/g | 0.21 pCi/g |
| | $^{137}$Cs, 0.113 pCi/g | 0.46 pCi/g |

### 3.1.7 Laboratory Analysis

Soil samples will be collected from the RBAs and sent offsite to an analytical laboratory for various analyses. The analytical methods and the radionuclides being analyzed for are presented in the SAP and are summarized in **Table 3-4**. The SAP provides additional guidance on soil sampling, chain-of-custody, laboratory analysis, and quality assurance/quality control requirements.

Table 3-4. Analytical Sample Summary

| Analytical Method | Radionuclide |
|---|---|
| Gamma Spectroscopy<br>(gamma-emitting ROCs and naturally occurring radionuclides) | $^{137}$Cs<br>$^{226}$Ra (equilibrated; via $^{214}$Bi and/or $^{214}$Pb)<br>$^{238}$U Series ($^{238}$U via protactinium-234m, $^{214}$Pb, $^{214}$Bi)<br>$^{232}$Th Series ($^{228}$Ac, $^{212}$Pb, $^{212}$Bi, $^{208}$Tl)<br>$^{40}$K<br>$^{241}$Am |
| Alpha Spectroscopy<br>(alpha-emitting ROCs and naturally occurring radionuclides) | $^{239}$Pu /$^{240}$Pu<br>$^{241}$Am<br>$^{226}$Ra<br>Thorium ($^{232}$Th, $^{230}$Th, $^{228}$Th)<br>Uranium ($^{238}$U, $^{235}$U, $^{234}$U) |
| Radon Emanation (Lucas Cell)<br>(to support future NORM evaluations) | $^{226}$Ra |
| Gas Flow Proportional Counting | $^{90}$Sr |

Notes:

$^{208}$Tl = thallium-208

$^{212}$Bi = bismuth-212

$^{212}$Pb = lead-212

$^{214}$Bi = bismuth-214

$^{214}$Pb = lead-214

$^{228}$Ac = actinium-228

$^{228}$Th = thorium-228

$^{230}$Th = thorium-230

$^{234}$U = uranium-234

$^{238}$U = uranium-238

$^{240}$Pu = plutonium-240

$^{241}$Am = americium-241

## 3.2 Survey Implementation

Prior to initiating the RBA characterization field activities, several premobilization and mobilization steps will be performed to ensure that work can be performed in a safe and efficient manner.

### 3.2.1 Premobilization Activities

The primary premobilization tasks include training of field personnel, procurement of support services, and obtaining access to onsite and offsite RBAs. Coordination with the City of San Francisco will be conducted to facilitate access and approval for sampling and ground disturbance activities at McLaren